Chapter Five:

Bearings, Beams, and Girders

This chapter focuses on the first steps in the construction of a bridge superstructure: the placement of bridge bearings, beams, and girders. The following items and their related inspection concerns will be discussed:

- Types and functions of bridge bearings;
- Installation of bearings;
- Structural steel;
- Pre-stressed concrete beams;
- Storage and handling of structural members; and
- Erection of structural members.

Bearings

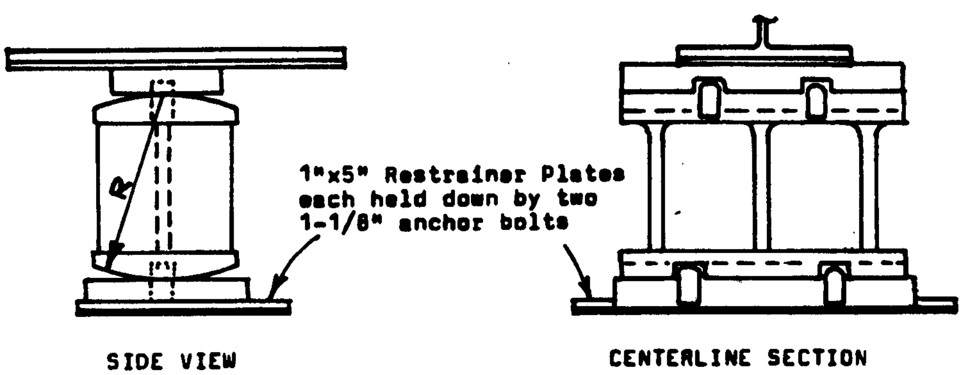
Most people think of bridges as static structures, incapable of movement. But anyone who has ever stood on a long bridge in a strong wind or one that's carrying heavy traffic knows different. Bridges move. They sway, they vibrate, and they twist and bend.

The bridge movements that most concern Certified Technicains are caused by temperature changes. As temperatures rise, parts of a bridge, particularly in the superstructure, expand; they get longer. As the temperature falls, the same parts contract; they get shorter. The movement may be barely discernible; a fifteen-degree change in temperature may cause less than an eighth of an inch change in the length of a hundred-foot span. But while the movement itself may be slight, the force behind it is tremendously powerful, and unless a bridge is designed to accommodate the movement, that force will eventually tear it apart.

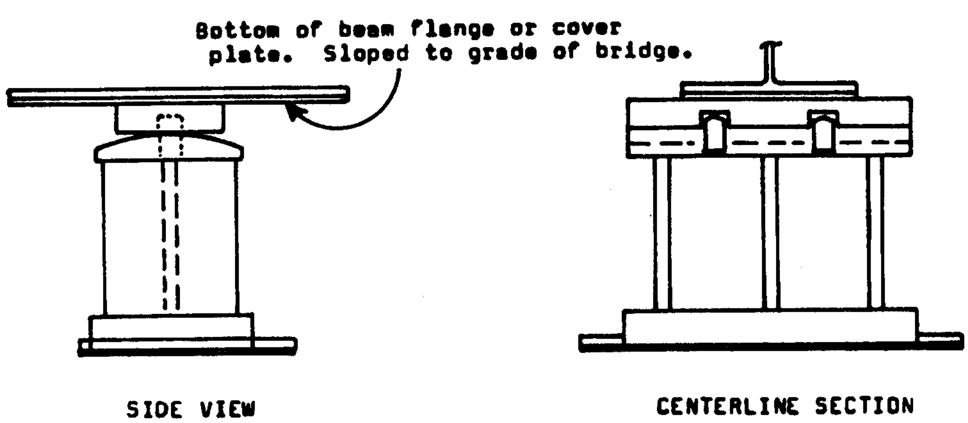
Bridge movement due to temperature changes is accommodated mainly through the use of *bearings,* the devices that connect the structural members of the superstructure (beams and girders) to the supporting units of the substructure (bents, abutments and piers). When designed and installed correctly, bearings permit the superstructure to move smoothly over the substructure without pushing those supporting units out of position.

Expansion vs. Fixed

Bearings may be classified as either *expansion* or *fixed.* Expansion bearings are designed to permit movement. As the beam or girder expands and contracts, expansion bearings, according to their design, will slide, rock, roll, or deflect along with it. Fixed bearings on the other hand, are designed to hold the structural member above it in place. Some fixed bearings will permit a slight degree of *rotational* movement, but generally nothing back and forth. All but the shortest spans will have at least one fixed bearing and one expansion bearing under each structural member to accommodate longitudinal movements.



EXPANSION BEARING ASSEMBLY



FIXED BEARING ASSEMBLY

Bearing Designs

There is a wide variety of bearing designs. The current trend in bearing design is toward simplicity: fewer moving parts, simpler to install and maintain.

Classification of Bridge Bearings by Function

1. Sliding Plates
   a. Steel on steel
   b. Steel on bronze
   c. Lead sheets between steel plates
   d. Bronze plates with graphite inserts
   e. TFE sliding on stainless steel
      (1) Steel plates faced with TFE
      (2) Fabric pads faced with TFE
      (3) Elastomeric pads faced with TFE
   f. Felt, oil and graphite, tar paper

2. Rolling Devices
   a. Roller nests
   b. Single rollers
   c. Segmental rockers
   d. Pinned rockers
   e. Rack and pinions
   f. Steel balls

3. Linkage or eyebar devices
   a. Simple link hangers
   b. Compression-tension struts
   c. Pin connections permitting rotation but no horizontal movement

4. Elastomeric devices
   a. Simple elastomeric pads (or combined with TFE)
   b. Stacked pads with intermediate restraining layers
   c. Circular restrained or "pot" bearings

5. Other devices
   a. Hydraulic cylinders or dash-pots
   b. Floating arrangements
   c. Spherical bearings

6. Structural flexibility
   a. Timber structures
   b. Tall flexible piers
   c. Curved bridge designs

7. Integral End Bents
   a. Monolithic pour of approach, deck and end bent
   b. A-1 joint between approach slab and deck
   c. Bearing portion of beams encased with concrete

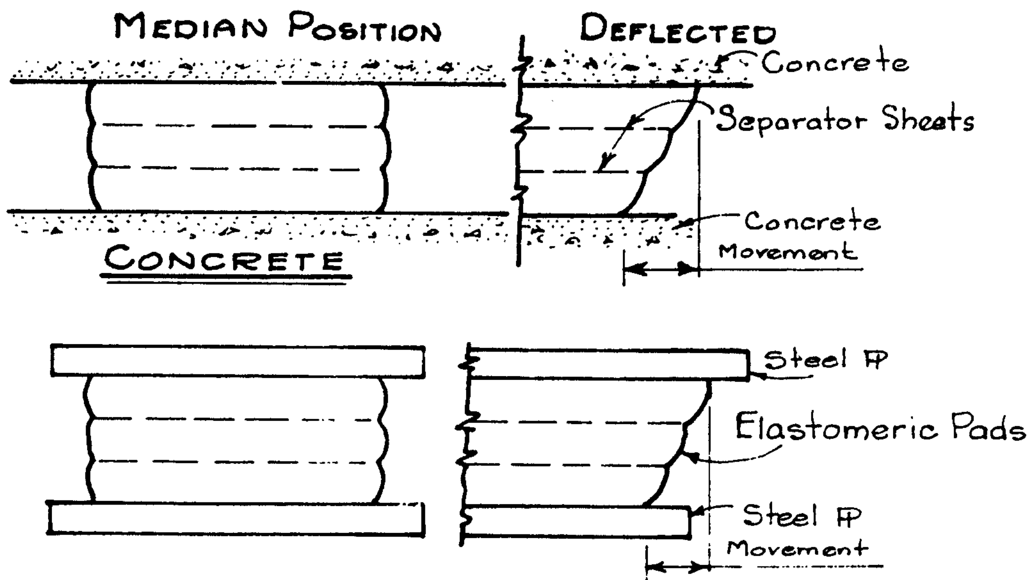
The Department has settled primarily on two types of bearing devices. For concrete structural members, the favored bearing is the elastomeric pad device. For steel beam and girder construction, both elastomeric bearings and steel bearing assemblies are common. Over the last several construction seasons, however, the use of integral end bents has become more and more common. This design includes fixed beams at the end bents with the bearing portion of the beams encased in concrete. The approach slab and deck are poured monolithic on the bent wall without the placement of any expansion material. The concept of this design is to prevent any road salt, moisture or other foreign material from reaching the beams at the bearing position. This has been a historical problem as the beams begin to deteriorate substantially worse at the ends. The joint between the deck and approach slab is sealed with a standard A-1 joint.

Elastomeric Bearings

Elastomeric bearings meet most of the demands of modern bearing design. They are simple devices to install and maintain; they don't freeze, corrode or deteriorate. About the only things that would cause an elastomeric bearing to fail, short of an earthquake, are inferior materials, incorrect design or improper installation.

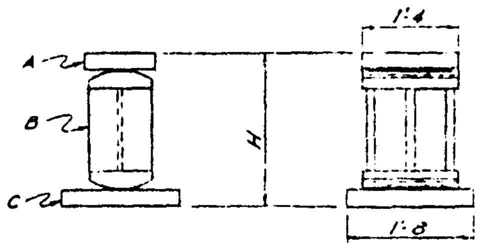
Elastomeric bearings consist of layers of natural or synthetic rubber (neoprene) that are separated by thin sheets of steel or fabric. When the structural member expands or contracts, the bearings absorb the movements by stretching or *deflecting* along with it. Because of their inherent ability to accommodate movement, elastomeric bearings are almost always used as *expansion* bearings

Elastomeric bearings may be secured to the bearing areas on the bridge seats in one of three ways. They may be bonded or "vulcanized" to a steel bearing pad that is secured to the bridge seat with anchor bolts; they may be glued in place through the use of special adhesives; or, because elastomeric bearings have shown little tendency to "walk," they may be set in place simply by the weight of the members they support. This last method, however, is good in theory only because it doesn't safeguard against unusual conditions such as movements caused by collisions. Bridge Standard Drawing 707-BEBP-01 to 03 provides additional details on elastomeric bearing design and usage.



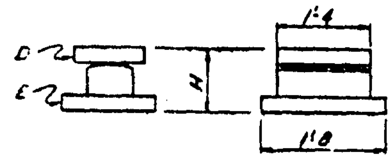
Steel Bearings

The most common type of steel expansion bearings or *shoes* used by the Department consists of three major parts: a top shoe, an expansion roller, and an expansion plate. The top shoe, sometimes called a sole plate, connects the expansion roller to the beam or girder; the expansion roller is curved at the top and bottom to accommodate longitudinal movement through a rocking motion; the expansion shoe, sometimes referred to as a masonry plate, connects the expansion roller to the bridge seat or to a recessed *anchor* plate: The bolts that connect the expansion roller to the top shoe and the expansion plate are set into slightly oversized or slotted holes. The extra room in the bolt holes gives the roller enough play to rock slightly backward or forward, depending on the movement of the member it supports.



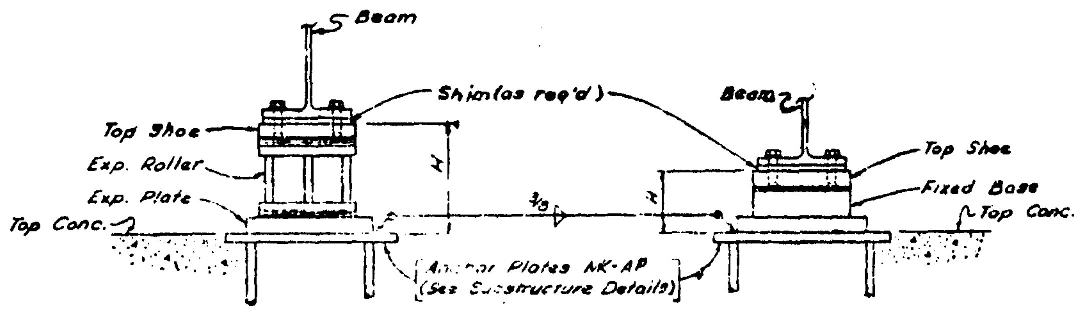
EXPANSION SHOE

SHOE TYPE	MAX. REACTION	SHOE ASSEMBLY			H
		A	B	C	
E-4	137ᴷ	TS-4	ER-4	EP-4	1'-6½
E-5	200ᴷ	TS-5	ER-5	EP-5	1'-7
E-6	300ᴷ	TS-6	ER-6	EP-6	1'-3¾



FIXED SHOE

SHOE TYPE	MAX. REACTION	SHOE ASSEMBLY		H
		D	E	
F-5	225ᴷ	TS-5	FB-5	7½
F-6	309ᴷ	TS-6	FB-6	7¾



EXPANSION SHOE ASSEMBLY

FIXED SHOE ASSEMBLY

The *fixed* shoe or bearing device also has three sections: a top or sole plate, a *fixed* roller, and a bottom, masonry plate called a fixed base. The curved surface of the fixed roller allows for a slight degree of rotational movement but none back and forth. Anchor plates are also used on some fixed shoe assemblies to connect them to the bridge seat.

Sheet Number 711-BSTS-01 to 04 of the standard bridge drawings supplies additional steel shoe details.

Bearing Installation and Adjustments

Preparations

Before permitting the contractor to proceed with the installation of the bearing devices, the PE/PS or the Certified Technician should make sure the following items have been taken care of.

- Bearings are of the design specified in the plans;
- All materials have been approved by Materials and Tests;

- Check General Plan sheet for *general* location of fixed and expansion bearings; use *detail* sheets for exact layout of bearings and anchor bolts.

- Each bridge seat has been checked for the proper elevation.

- The bridge seats are level to insure full contact with the bottom of the bearing devices. Grinding is done if necessary.

- Holes for the anchor bolts have been either formed or drilled in the proper location in relation to span lengths, centerline of girder and centerline of bearing.

Every bearing plate must be accurately positioned and leveled in both directions.

Temperature Adjustments

After the placement of the structural members, the position of steel *expansion* bearings must be adjusted for temperature; fixed bearings and elastomeric bearings need no adjustment, provided they've been installed in the correct position in the first place.

Before making any final adjustments for temperature to expansion bearings the contractor should remove any supporting falsework so that the structural members are under "dead load." Also, the anchor bolts in the corresponding fixed bearings should be permanently set in the bearing seats and grouted.

Bearing adjustments for temperature are based on the following assumptions:

- a beam or girder length of 100 feet;

- a mean temperature of 68 degrees;

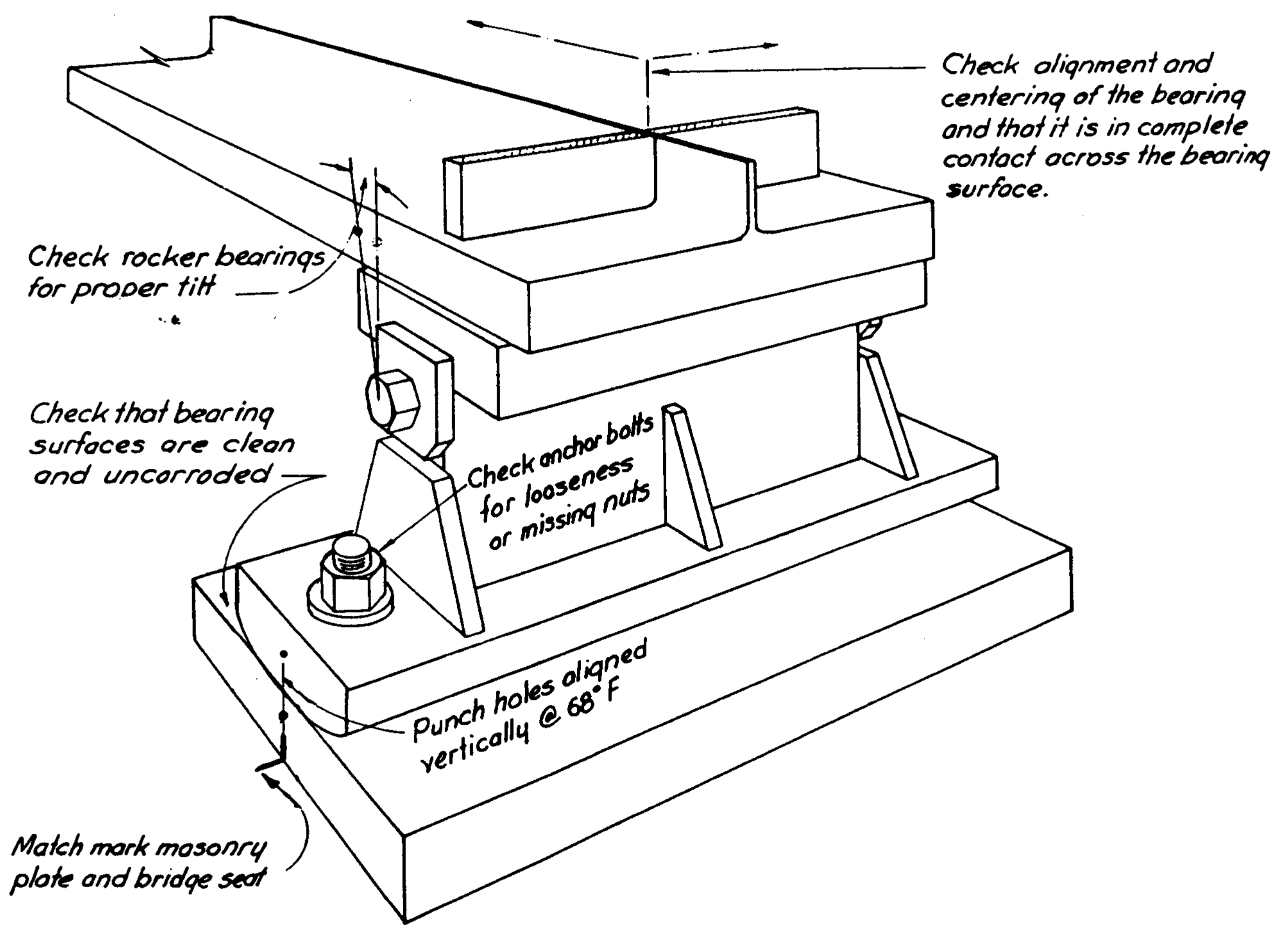
- 1/8 inch of movement for every 15 degrees above the mean temperature.

This means that at 68 degrees the expansion roller in the steel shoe assembly should be completely vertical, not tilted away or toward the end of fixed bearing. When temperatures are above 68, the roller should tilt *away* from the end of fixed bearing; at temperatures below 68, the roller should tilt *toward* the end of fixed bearing. The exact degree of tilt or offset from the vertical depends on the actual length of the beam or girder and its temperature at the time of installation.

Additional allowance for bearing adjustments have to be made for *deflection.* Deflection is the lengthening of the beams as they are loaded and the camber decreases.

In general, computing temperature adjustments and adjustments for deflection will be done by the Project Engineer or the Central Office engineering staff, and the adjustments themselves will be performed by the contractor. Technicians must be aware of the necessary adjustments and see that they are done. This may simply involve visually examining the position of each expansion roller to see if it is tilted in the direction one would expect for the temperature and that all rollers show the same degree of offset from the vertical. Once everything lines up correctly, the anchor bolts may be grouted permanently to the bridge seats.

The plans will specify anchor bolt lengths and how far down the bolts should be set into the bridge seat -- usually a minimum of one foot. The threaded portion of the bolt is typically four inches. After the anchor bolt nut has been tightened the required amount, the threads of the bolt are burred to prevent the nuts from being removed.



Structural Steel

The term "structural steel" generally refers to the steel beams and girders, as well as any transverse members such as diaphragms used to transfer loads from the bridge deck and other parts of a bridge's superstructure to the bearings. Structural steel must meet the material requirements listed in Section 910.02 of the Standard Specifications.

Beams and Girders

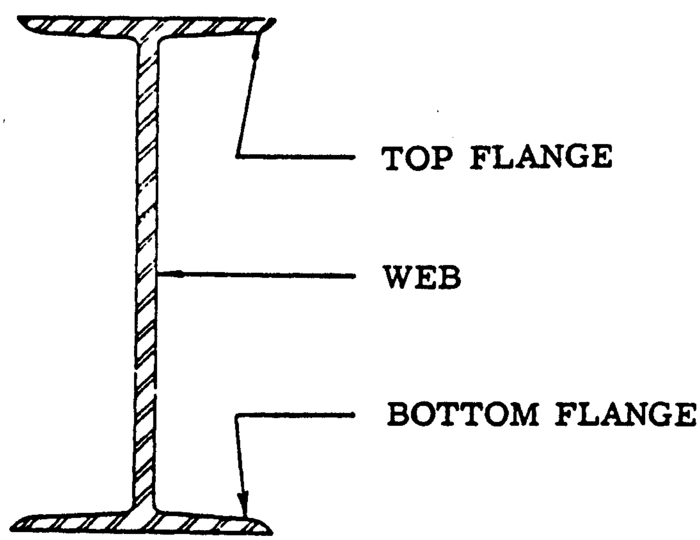
In discussing structural steel, the terms beam and girder have become almost interchangeable. To add to the confusion, a third term, "stringer," is also used in many parts of the country. All are I-shaped members consisting of a wide vertical section called a web and more narrow horizontal flanges on the top and bottom. The differences between beams and girders mainly concern size and fabrication methods.

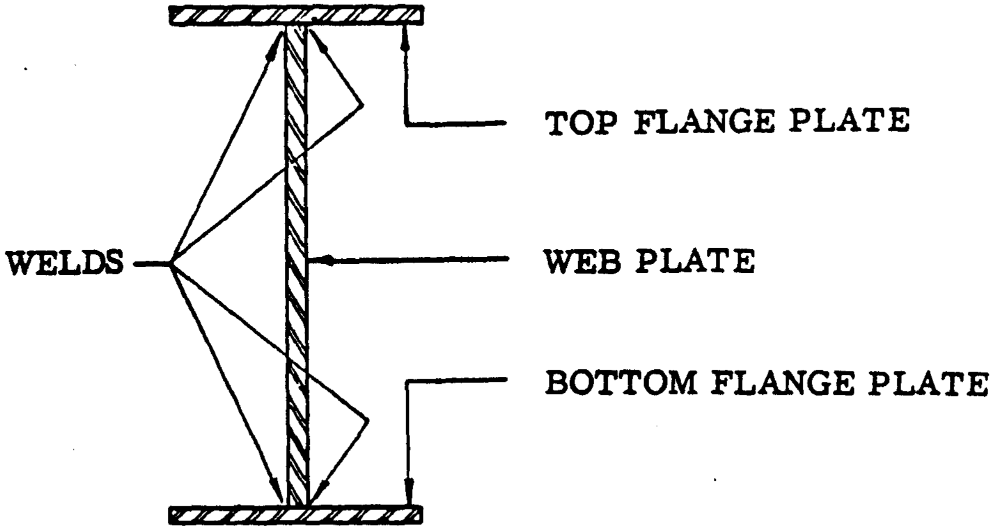
Beams are generally *milled* or *rolled* sections. They tend to be small in comparison to girders because their size is limited by the capacity of milling equipment.

A girder, on the other hand, can be made to virtually any size. That's because they're fabricated or ` `built up" rather than rolled. Fabricated girders consist of three plates that have been welded or riveted together to form an I-shaped member. Because of this method of fabrication such members are often referred to as *plate* girders.

ROLLED BEAM (ROLLED IN ONE PIECE)

This may also be termed a girder or stringer





WELDED GIRDER (SEPARATE WEB AND FLANGE:
PLATES WELDED TOGETHER)

This may also be termed a beam or stringer

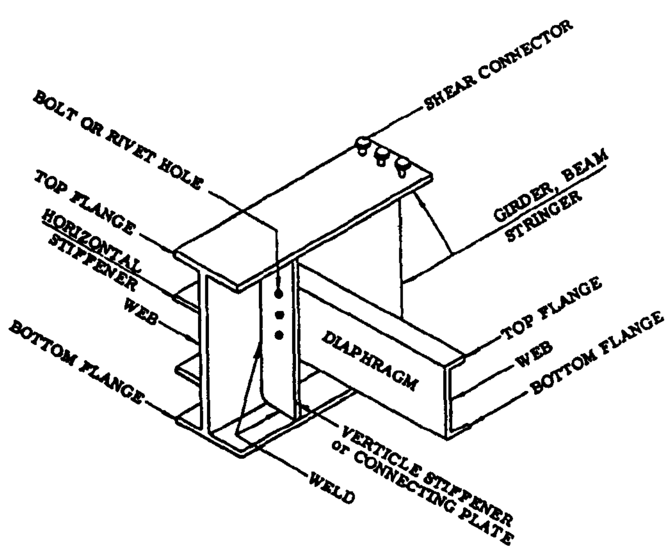
Additional Features

Stiffeners

All but the shortest section of structural steel will have a number of vertical braces called *stiffeners* attached to the web section to prevent it from buckling.

Diaphragms

Diaphragms are braces that are placed in between and connected transversely to adjacent beams or girders. Diaphragms provide the beams and girders with extra rigidity against wind forces.



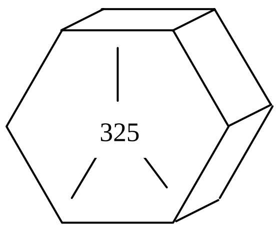
Beam Detail

Splice Plates

Splice plates are used to join steel members to form a longer section. Splice plates are bolted to the web and flange sections of the members through holes that have been drilled or reamed through the member either at the fabrication shop or in the field.

High-Strength Bolts, Nuts, and Washers

The fasteners used to secure splice plates and other connecting pieces must be in accordance with ASTM 325. High strength bolts will be identified by three lines and the mark "325" engraved on the heads. High-strength nuts and washers will be inscribed with three arced lines. All fasteners used for securing the structural steel must have these marks and must have been tested prior to use.

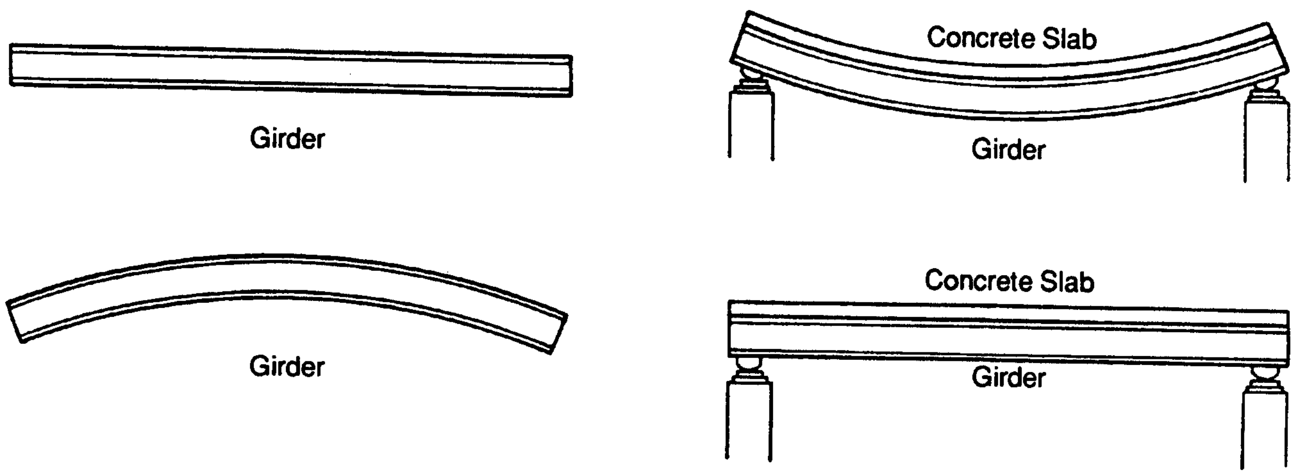


Shear Connectors

In order to prevent the concrete of a bridge deck from sliding over the structural steel, shear connectors or shear studs are welded to the top flange. These studs are later embedded in the concrete and act to join the structural steel to the deck to form an integral unit.

Camber

Nearly all beams and girders, both steel and concrete, are fabricated with some degree of *camber.* Camber is the slightly arched or convex curvature that's built into structural members to compensate for the deflection or flattening-out that occurs when the members are placed under a load. Without camber, the loads of the



superstructure would cause the members to sag; with camber, the members form a more aesthetic and uniform profile. The drawings below illustrate the effect of camber in an exaggerated degree.

Approval of Structural Steel

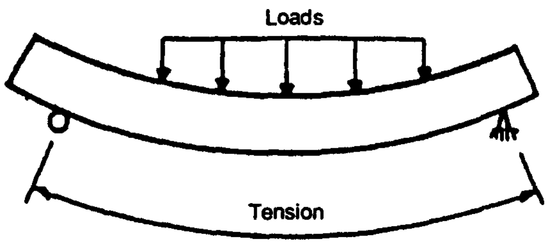
Structural steel must come from a manufacturer or fabricator. The fabricator must furnish four copies of the mill test reports to show that the steel meets the material requirements called for on the plans. Some structural steel must come from fabricators which are certified as per Article 711.04 of the specifications.

Structural Steel Plans

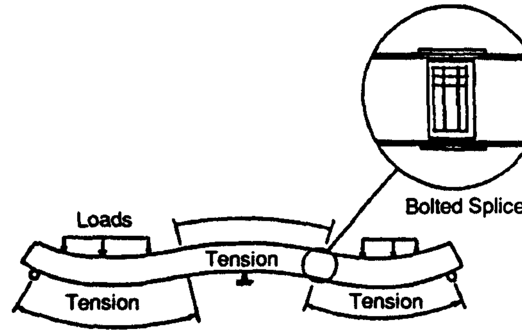
Contract Drawings

The Department's contract drawings for structural steel include a framing plan and various structural steel details. The framing plan includes the fabrication and erection notes that outline the material requirements (steel, bolts, paint, etc.). Other information on the framing plan includes the lengths of all structural steel members, the locations of splices, the amount of camber in the spans, the spacing of the shear connector studs, and so on. The detail sheets typically show such things as field splice elevations, splicing requirements, and bearing assembly details.

The detail sheet also includes a diagram to show which areas of the steel will be in tension and which area will be in compression. Compression and tension forces are mainly applied to the flanges of steel beams and



SIMPLE SPAN BEAM



CONTINUOUS SPAN BEAM

girders. On a simple span, compression is always focused on the top flange while the bottom flange is always in tension. But on continuous spans, areas under tension will change as the steel crosses over intermediate supports.

Certified Technicians should be aware of areas in tension because that's where a beam or girder is most likely to fail if it becomes damaged. Also, because heat can change the character of steel and weaken it, welding and cutting of structural steel may be done only where specified or approved. No welding should be performed for any reason on a flange or any other area that is or will be in tension.

Fabrication and Erection Drawings

The contractor must submit shop drawings that show in detail the plans for fabricating and erecting structural members that meet the requirements of the contract drawings. These plans should identify individual structural members, their location in the structure, and the total weight of the steel and other associated materials. The fabrication and erection plans are reviewed by the Project Engineer/ Supervisor for design features only; even if the plans are approved, the contractor remains responsible for the dimension, accuracy, and fit of the work.

The fabrication and erection plans must show a plan for *match marking* all reamed pieces such as diaphragms and splice plates. Match marks help prevent misfits because the pieces are assembled in the field in the same manner they were fabricated in the shop.

The approved fabrication and erection drawings should be checked against the contract drawings for conformance to the plans. Revisions to the contractor's drawings must be approved by the Project Engineer in writing.

Delivery and Storage

When the structural steel arrives, the technician should look for the Department's stamp or approval number on each beam or girder. Individual members are identified by the heat numbers on the mill test reports. Additional inspections include:

• Proper lengths and dimensions.

- Obvious defects or damage (nicks, cracks, bends), especially damage to the tension flange. Such damage is likely to worsen once additional loads are applied to the member.

- To minimize damage from handling, structural members should be stored as close as possible to the site where they'll be used.

- Structural members should be stored upright and off the ground. They should be supported at *all points of bearing* to prevent unnecessary deflection. Members should also be adequately braced to prevent them from tipping over.

- Beams and girders should be checked for the proper amount of camber with a string line or level. The desired amount of camber is shown in inches on the contractor's drawings or on the plans.

- Like members should be stored together so that any obvious errors in length and other dimensions will be easily noticed.

- Splice plates and other connecting pieces should be examined for and protected from rust, burrs, paint, oil, or other material that would prevent those pieces from making full contact with the structural members.

- All members and connecting pieces should be identified by match marks.

- Approved fasteners should be kept together and protected from the weather prior to their use in the structure.

Erection of Steel Members

Erection of the structural steel can begin only after the locations and the elevations of the bearing devices have been checked.

During the erection process, the Certified Technician should observe how well steel members line up with the bearing devices. Bearing elevations may be adjusted with shims as specified on the plans; any adjustments to alignment must be approved by the engineer.

Erection of the steel normally begins at the end of fixed bearing. Steel members should be placed in the order and in the locations according to the match marks shown on the contractor's erection plans. Although one member may look exactly the same as the next, there *can* be virtually indiscernible differences in degrees of camber and other dimensions.

As soon as possible after setting adjacent girders, the contractor should install enough diaphragms or cross-braces to secure the steel against the wind and to prevent them from being knocked over.

The Specifications state that the contractor must use at least 50 percent of the bolts necessary to secure diaphragms and splice plates to the steel members. At this stage of the operation, the bolts should not be tightened to more than a "snug tight" condition. The Specifications define snug tight as the tightness attained after a few impacts of an impact wrench or after the full effort of a man using an ordinary spud wrench. Final tightening of all bolts is held off until all structural steel is in position.

In general, bolts should be tightened at the nut while the head of the bolt is prevented from turning. Field conditions, however, may require tightening some bolts at the head. Washers should always go under the part that is turned, whether it's the nut or the bolt head.

The contractor may use *drift pins* to line up holes between the steel and diaphragms and splice plates only as long as the pins are used only to draw the parts into position. Drift pins should not be used to enlarge holes or to distort the metal.

It is essential that elevations of the splice joints be established before permanent connections are made.

For aesthetic reasons, bolts that are used to secure splice plates to the web section of exterior or fascia members should be installed with the head of the bolt on the outside face. This simply presents a neater appearance.

Once the preliminary bolting has been completed, the contractor must complete all connections. When possible, workers should start tightening the bolts in the center of a splice plate first and work out toward the edges. This helps bring the plate into full contact with the structural member.

Final Bolt Tension

Bolts in splices and diaphragms must be tightened to a minimum tension according to the size of the bolt. The table below from Section 711.63 shows the minimum bolt tension in pounds for a variety of bolt sizes. Again, only high-strength fasteners may be used.

BOLT TENSION FOR ASTM A 325 BOLTS

Bolt Size in inches	Minimum Bolt Tension* in pounds
1/2	12,050
5/8	19,200
3/4	28,400
7/8	39,250
1	51,500
1 1/8	56,450
1 1/4	71,700
1 3/8	85,450
1 1/2	104,000

*Equal to the proof load (length measurement method) given in ASTM A 325.

There are two methods of bolt tightening that can be used to achieve the correct bolt tension as specified in the above table: calibrated wrench tightening and turn-of-nut tightening. Installation of all high strength bolts shall be done in accordance with AASHTO Standard Specifications for highways and bridges, division II.

Calibrated Wrench Tightening

This method involves using a power or manual wrench that is not only capable of tightening the bolts to the specified tension, but also capable of indicating when that tension has been achieved.

The wrenches that are used in this method must be calibrated once a day while the final tightening operation continues. Calibration involves tightening at least 3 bolts of each size represented in the structure in a device that is capable of indicating actual bolt tension. The contractor must inform the PE/ PS of when the calibration will take place so that they may witness the procedure. The calibrated wrenches should be set to induce a bolt tension that is 5 to 10 percent in *excess* of the specified tension.

Power wrenches can be set to stall or cut out when the selected tension is achieved. The wrench should be capable of doing so within 10 seconds.

If manual torque wrenches are used, the torque indication corresponding to the calibration tension shall be noted and used in the installation of all high strength bolts.

The contractor should retighten all the bolts that were installed to the snug-tight condition during the erection of structural steel members; they may have become loose due to the tightening of the others.

Turn-of-Nut Tightening

Turn-of-nut tightening method of bolt tensioning requires that all bolts be installed and brought to a snug condition before final tightening takes place. Final tightening is accomplished by turning the nut or the bolt head a fraction of a turn beyond snug tight -- 1/2 turn for bolts 8 inches long or 8 diameters or less; 2/3 turn for bolt lengths exceeding 8 inches or 8 diameters; and 3/4 turn for all bolts used to connect sloping pieces. For

NUT ROTATION(1) (2) FROM SNUG TIGHT CONDITION

Disposition of Outer Faces of Bolted Parts

Both faces normal to bolt axis, or one face normal to axis and other face sloped(3) (bevel washer not used).		Both faces sloped(3) from normal to bolt axis (bevel washers not used)
Bolt length(4) not exceeding 8 diameters or 8″.	Bolt length(4) exceeding 8 diameters or 8″.	For all lengths of bolts.
½ turn	⅔ turn	¾ turn

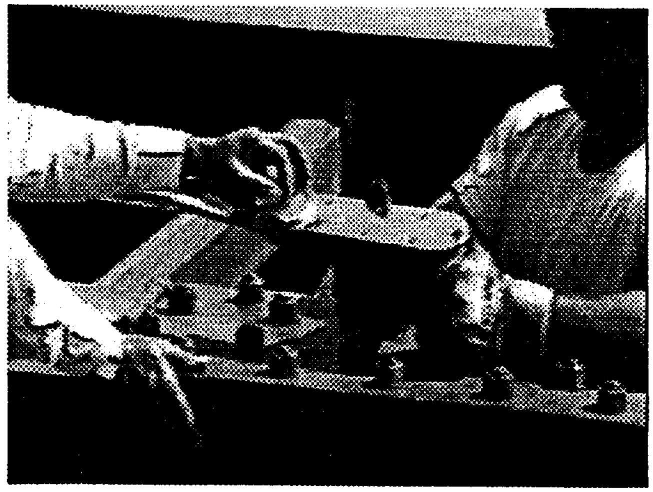
(1) For coarse thread heavy hexagon structural bolts of all sizes and lengths and heavy hexagon semi-finished nuts.
(2) Nut rotation is rotation relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation: ⅙ of a turn over and nothing under.
(3) Slope 1:20 maximum.
(4) Bolt length is measured from underside of head to extreme, end of point.

splice plates and diaphragms, the typical requirement is 1/2 turn from the snug tight condition.

Inspection

Whatever method the contractor uses to achieve the specified bolt tension, the installation and tightening of bolts should be observed to determine that all bolts are tightened properly according to the chosen method.

Because it's impractical to have a technician observe the tightening of every bolt in the structure, the Specifications call for the random inspection of at least 10 percent of the bolts in each splice or other joint. In no case should the number of bolts to be inspected in any location be fewer than two.



If the inspecting wrench cannot turn a bolt head or nut in the tightening direction at the job inspecting torque (the average torque needed to turn the three bolts in the calibrating device five degrees, plus 5-10 percent), then the connection is accepted. If any bolt head or nut in the sample is turned by the application of the inspecting wrench at the job-inspecting torque, then all bolts in the connection must be tested. All bolts failing to meet the specified tension have to be retightened and retested.

Final Adjustments to Bearings (End-Owe)

After all structural steel has been placed and bolted, the contractor has to adjust the steel longitudinally so that the distance from the backwall or mud wall to the centerlines of bearings on the abutments or end bents is equal on both sides of the structure. This operation is often referred to as " endowe"; some adjustment is "owed" to the ends of the steel.

Once the longitudinal adjustments have been made, the anchor bolts in the fixed bearings may be grouted. Finally, after the grout in the fixed bearings has set, the contractor may adjust the expansion bearings for temperature, then set the anchor bolts there as well.

Field Welding

As previously stated, welding of structural steel may only be performed where specified on the plans or otherwise approved. Improper welding can create many problems up to and including structural steel failure.

Certification of Welders and Materials

Because it is such an important part of the bridge construction process, all welding on State projects must be done by certified welders who use approved materials. Certified welders are required to carry an identification card; the PE/PS should make sure it's up to date and retain a photocopy for the project file.

Welding materials, specifically rods or electrodes, must also be approved. If there's any doubt of whether or not a particular size, type, or brand of electrode is approved, the Certified Technician should consult the PE/PS before allowing welding to proceed or to continue with the use of that material.

Standard welding symbols are shown in the appendix; if you're not familiar with them, take the time now.

Fillet Welds

Fillet welds are the most common type of field weld used in the erection of structural steel. They have a triangular cross section and are used to join two surfaces approximately at right angles to each other in a lap joint, a T -joint or a corner joint.

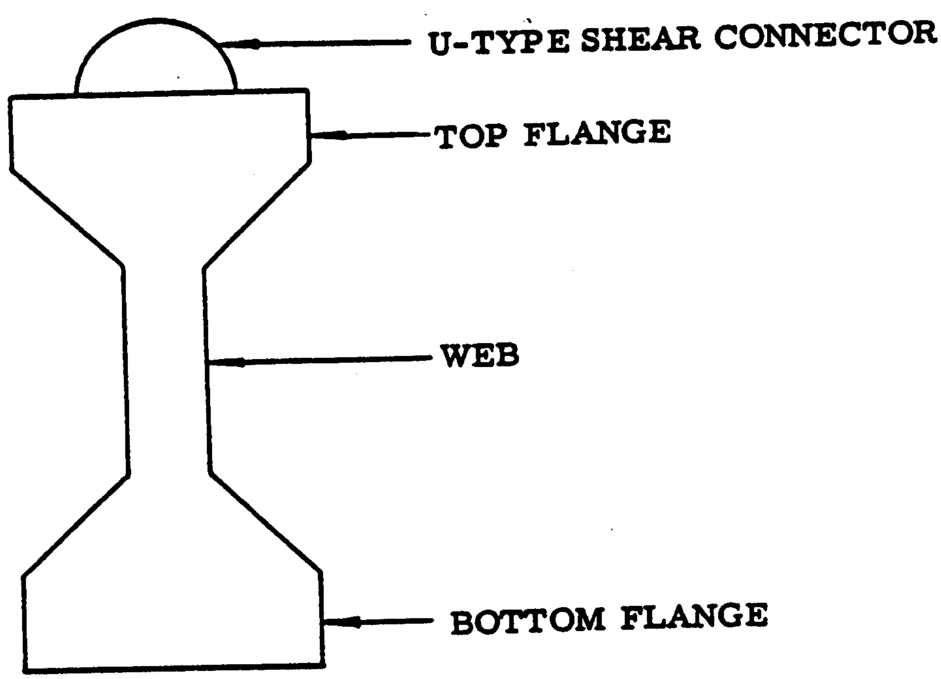
There are quite a few sophisticated ways to inspect welds -- radiographic or X-ray, ultrasonic, magnetic particle inspections, and so on. Certified Technicians in the field, however, must rely on visual inspection of welds. Are they in the right place? Are they the right size? Has the slag been removed?

In addition to welding symbols, the appendix includes a page from the Department's *General Instructions To Field Employees* manual. It shows drawings of desirable, acceptable, and unacceptable fillet and butt welds.

CONCRETE MEMBERS

Concrete members such as I-beams and box girders are used as alternatives to structural steel in many bridge superstructures. When constructed and erected properly they can provide years of service comparable to steel. In the past, concrete members have been used primarily in the construction of simple spans of lengths up to 100 feet, but new construction techniques and designs have made them suitable for longer spans.

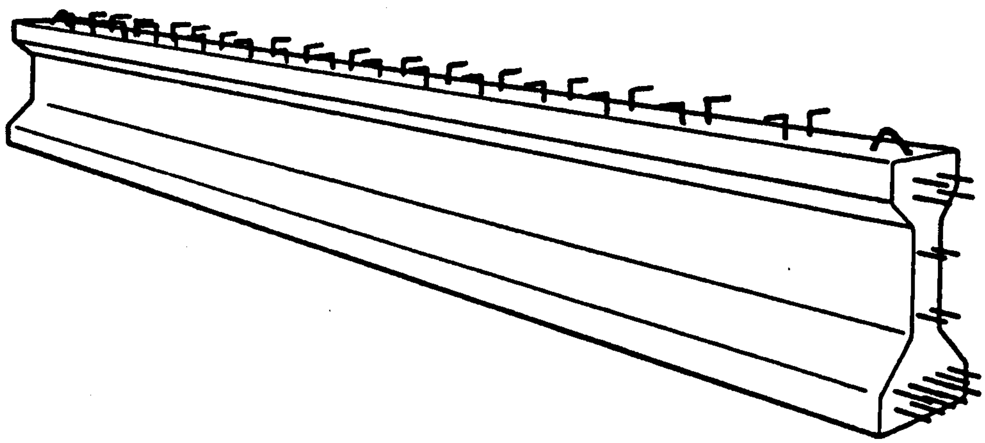
Pre-cast concrete beams are made in a concrete fabricating yard by pouring concrete into metal I shaped forms and allowing it to harden until it achieves a specified compressive strength, usually between 4500



PRESTRESSED CONCRETE STRINGER
This may also be termed a beam or stringer

pounds per square inch at 28 days. The forms are shaped to produce beams to the required dimensions. Reinforcing steel bars placed inside the forms bond with the concrete and give it tensile strength.

Concrete beams may also be *pre-stressed.* Prestressing concrete involves stringing steel strands in layers through the beam forms and embedding them in the concrete. Most of the strands are concentrated in the lower part of the beam, where tensile stresses will usually be the greatest.



When the concrete reaches a specified compressive strength, typically 4000 pounds per square inch, the strands are placed under stress by pulling them extremely taut with jacks or similar devices. After the concrete reaches a compressive strength of 5000 pounds per square inch, the strands are released. Their natural tendency is to contract back to their original lengths prior to stressing. But because of the bond they've developed with the concrete, they can contract only slightly and remain in tension.

The tension of the strands is so great that when they contract, they pull the concrete in on itself, compressing it and producing *camber* in the beam. Because of their camber and their enhanced tensile and compressive strength, pre-stressed concrete beams generally can support greater loads than ordinary reinforced beams of the same size. Without camber, the beams would deflect and sag under heavy loads. In addition, pre-stressed beams require less concrete and so are lighter and easier to handle.

The construction requirements for concrete beams are outlined in Section 707 of the Standard Specifications. The fabricator produces the beams in accordance with those specifications and to the sizes and dimensions shown on the contract drawings. The fabrication plans and the contractor's erection drawings must be approved, just as they must for steel beam construction. Of course, the materials and methods used in the construction of concrete beams are more the certified technician in the concrete plant’s responsibility than the field Certified Technician’s. The field Certified Technician’s responsibility begins when the beams arrive at the project site.

Delivery, Storage, and Handling

Prior to the delivery of the concrete members the Certified Technician should review the following references:

- Contract drawings including the General Plan sheet, substructure detail sheets, beam erection plan, floor details;
- Concrete fabricator's *approved* fabrication drawings;
- Applicable special provisions and standard drawings; and
- Section 707.08-11 of the Standard Specifications.

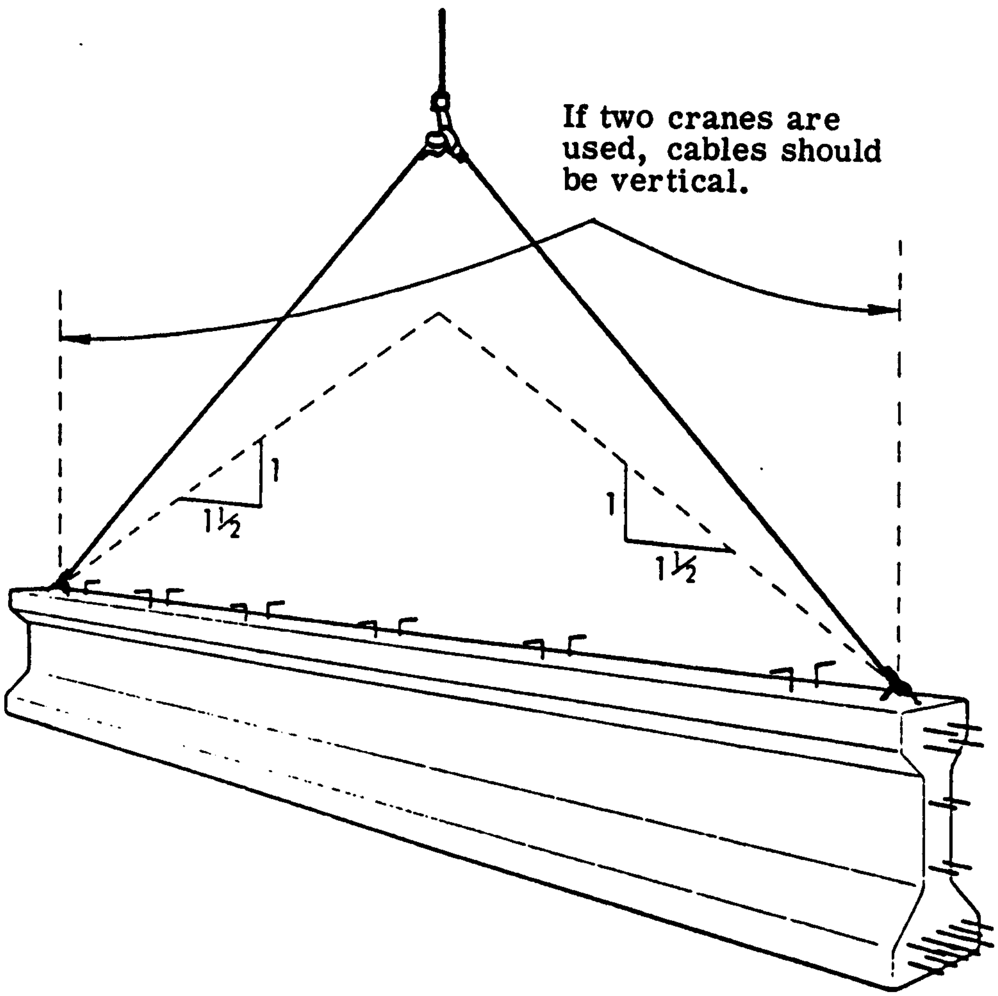
When the concrete beams arrive on the jobsite, collect the yellow. inspection cards that should accompany each member showing that it's been inspected at the producer's plant. Also look for the "State of Indiana" outline stamped on the beam indicating it was produced for use on a State project.

Concrete beams require the same careful handling and storage as steel members. Beams must be stored upright and supported off the ground. The supports must be level and located at the beams' centerlines of bearing. That will reduce internal stresses that could cause unnecessary twisting or deflection.

The technician should check all beams for cracking, spelling, and other damage to the concrete. Small hairline cracks are usually due to shrinkage and are not critical to the strength of the beam: Large cracks indicate mishandling. A beam that has been dropped, or one that has had something dropped on it, may have been weakened structurally. The PE/PS should be made aware of any significant damage to concrete members.

Like steel members, concrete beams use shear connectors to tie them to the concrete deck. The connectors, typically bent reinforcing steel, must be in good shape -- clean, free of rust, and bent only as shown on the plans.

The fabricator may have also located *lifting hooks* on the top side of the beams. These, again, must conform to the plans as far as their design and placement. Beams should be picked up at those points only. The pick-up cable should be long enough that it can maintain a safe slope. One-and-a-half to one is a safe minimum. A flatter slope could produce enough stress on the tension (bottom) flange to weaken it. The Specifications permit the use of other methods of lifting as long as they are in accordance with the beam fabricator's recommendation. The recommended lifting methods will be noted on the fabricator's plans.



Erecting Concrete Beams

During the erection of concrete beams, the Certified Technician's major responsibilities involve seeing that the erection plans are followed and that each member is set in the proper location. The beams should be match marked to locations shown on the plans.

The members should be erected in the sequence shown on the plans. Ends of fixed bearing are typically installed first. All adjustments should be made while the beams are supported by the lifting devices, not when they're resting on the bridge seats. Don't allow the contractor to use pinch or crow bars to move beams because they can chip and damage the concrete. If the beams were constructed correctly and the substructure units are properly aligned, only minor adjustments will be needed to get the beams seated on the bearing areas.

Securing Beams to Bearing Areas

Concrete beams must make full contact with the bearing areas. They are typically secured to the bearing areas with dowel bars that are inserted through pre-cast holes that go through the beams and down into holes in the bridge seats. These holes will be filled with grout at the fixed ends of beams and with flexible joint filler at the expansion ends. Some beams may be further secured to the bearings by plates or angles that have been cast into the sides or bottoms of the beams.

Diaphragms

Like steel beams, concrete beams will typically require diaphragms to provide them with lateral support. Diaphragms for I-beams have to be formed to the dimensions shown on the plans and cast in place; they're not pre-cast like the beams they connect. The reinforcing steel for diaphragms is inserted into holes that have been cast partway through the inside web section of fascia beams and all the way through the web section of interior beams. The plans may require the steel to be installed as soon as adjacent beams are placed. Forming and pouring the diaphragms takes place *after* the erection of the beams and *before* the deck forms are installed

Final Approval of Concrete Members

The contractor is not permitted to grout dowels or anchor bolts, construct forms, or pour concrete for any diaphragms or for the bridge deck until the PE/PS has received complete documentation of the acceptability of the concrete members and bearing pads, including satisfactory lab results and materials certifications.

Measurement and Payment

Precast or pre-stressed structural members are measured by the number of members installed or by the square feet of roadway surface, as indicated on the plans or in the contract. If the contractor is to be paid a lump sum price for the members, then no measurement is necessary.

Payment for concrete structural members is to be made at the contract lump sum, unit price per each, or per square foot of roadway surface for the types and sizes specified, completed in place.

The cost for the reinforcing steel, bearings, and other incidental items necessary to complete the work is included in the cost for the structural members.